A UNITED STATES DEPARTMENT OF COMMERCE PUBLICATION

NBS Voluntary Product Standard

PS 52-71

Polytetrafluoroethylene (PTFE) Plastic Tubing

A Voluntary Standard Developed by Producers, Distributors, and Users With the Cooperation of the National Bureau of Standards

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

UNITED STATES DEPARTMENT OF COMMERCE

Peter G. Peterson, *Secretary*

NATIONAL BUREAU OF STANDARDS
Lewis M. Branscomb, *Director*

Voluntary Product Standard

PS 52-71

Polytetrafluoroethylene (PTFE) Plastic Tubing

Technical Standards Coordinator: L. H. Breden

Abstract

This Voluntary Product Standard covers commercially available PTFE tubing intended for chemical, mechanical, and electrical applications. Included are requirements and methods of test for materials, dimensions, and physical and chemical properties. A method for identifying products which comply with this Standard is provided.

Key words: Chemical, mechanical, and electrical tubing; fluorocarbon plastic tubing; plastic tubing, polytetrafluoroethylene; PTFE tubing; tubing, PTFE-fluorocarbon.

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Contents

VOLUNTARY PRODUCT STANDARDS

Voluntary Product Standards are standards developed under procedures established by the Department of Commerce (15 CFR Part 10, as amended, May 28, 1970). The standards may include (1) dimensional requirements for standard sizes and types of various products, (2) technical requirements, and (3) methods of testing, grading, and marking. The objective of a *Voluntary Product Standard* is to establish requirements which are in accordance with the principal demands of the industry and, at the same time, are not contrary to the public interest.

Development of a VOLUNTARY PRODUCT STANDARD

The Office of Engineering Standards Services of the National Bureau of Standards has been assigned by the Department of Commerce the responsibility to work closely with scientific and trade associations and organizations, business firms, testing laboratories, and other appropriate groups to develop *Voluntary Product Standards.* The Bureau has the following role in the development process: It (1) provides editorial assistance in the preparation of the standard; (2) supplies such assistance and review as is required to assure the technical soundness of the standard; (3) acts as an unbiased coordinator in the development of the standard; (4) sees that the standard is representative of the views of producers, distributors, and users or consumers; (5) seeks satisfactory adjustment of valid points of diagreement; (6) determines the compliance with the criteria established in the Department's procedures cited above; and (7) publishes the standard.

Industry customarily (1) initiates and participates in the development of a standard; (2) provides technical counsel on a standard; and (3) promotes the use of, and support for, the standard. (A group interested in developing a *Voluntary Product Standard* may submit a written request to the Office of Engineering Standards Services, National Bureau of Standards, Washington, D.C. 20234.)

A draft of a proposed standard is developed in consultation with interested trade groups. Subsequently, a Standard Review Committee is established to review the proposed standard. The committee, appropriately balanced, includes qualified representatives of producers, distributors, and users or consumers of the product being standardized. When the committee approves a proposal, copies are distributed for industry consideration and acceptance. When the acceptances show general industry agreement, and when there is no substantive objection deemed valid by the Bureau, the Bureau announces approval of the *Voluntary Product Standard* and proceeds with its publication.

Use of a VOLUNTARY PRODUCT STANDARD

The adoption and use of a *Voluntary Product Standard* is completely voluntary. *Voluntary Product Standards* have been used most effectively in conjunction wtih legal documents such as sales contracts, purchase orders, and building codes. When a standard is made part of such a document, compliance with the standard is enforceable by the purchaser or the seller along with other provisions of the document.

Voluntary Product Standards are useful and helpful to purchasers, manufacturers, and distributors. Purchasers may order products that comply with *Voluntary Product Standards* and determine for themselves that their requirements are met. Manufacturers and distributors may refer to the standards in sales catalogs, advertising, invoices, and labels on their product. Commercial inspection and testing programs may also be employed, together with grade labels and certificates assuring compliance, to promote even greater public confidence. Such assurance of compliance promotes better understanding between purchasers and sellers.

Polytetrafluoroethylene (PTFE) Plastic Tubing

Effective November 15, 1971 (See section 6.)

(This Standard, initiated by The Society of the Plastics Industry, Inc., has been developed under the *Procedures for the Development of Voluntary Product Standards*, published by the U.S. Department of Commerce. See Section 7, *History of Project*, for further information.)

1. PURPOSE

The purpose of this Voluntary Product Standard is to establish nationally recognized dimensions and significant quality requirements for plastic tubing when made of polytetrafluoroethylene (PTFE) resin and intended for electrical, chemical, and mechanical applications. This Standard is intended to provide producers, distributors, and users with a basis for common understanding of the characteristics of this product.

2. SCOPE AND CLASSIFICATION

2.1. Scope—This Voluntary Product Standard covers commercially available PTFE tubing intended for chemical, mechanical, and electrical applications. It provides requirements and methods of test for materials, dimensions, and physical and chemical properties. A method for identifying products which comply with this Standard is provided.

2.2. Classification—The plastic tubing covered by this Standard is classified as follows:

Grade A—This grade of PTFE tubing is intended for electrical uses. There are no subtypes or subclasses.

Grade B—This grade of PTFE tubing is intended for chemical and mechanical uses. There are two subtypes and three subclasses for each subtype:

Type I—This type of PTFE tubing has wall thicknesses ranging from 0.040 inch to 0.070 inch.

Type II—This type of PTFE tubing has wall thicknesses ranging from 0.030 inch to 0.055 inch.

Type I and Type II include the following classes:

Class A—general-purpose tubing.

Class B—flexible tubing—processed for maximum flexibility and fatigue resistance.

Class C—stress-relieved tubing—processed for minimum

3. REQUIREMENTS

3.1. General—Products represented as complying with this Voluntary Product Standard shall meet all of the requirements specified herein.

3.2. Material—The tubing shall be made of polytetrafluoroethylene (PTFE) resin conforming to the requirements of Type III resin as described in the American Society for Testing and Materials (ASTM) D 1457–69, *Standard Specification for TFE-Fluorocarbon Resin Molding and Extrusion Materials*,[1] except that a maximum of 2 percent by weight of additive is permissible.

3.3. Dimensions and tolerances—The dimensions and tolerances of the tubing shall be as specified in table 1 or 2 when the tubing is measured in accordance with 4.3.

[1] Later issues of the ASTM publications referenced in this Standard may be used providing the requirements are applicable and consistent with the issues designated. Copies of ASTM publications are obtainable from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

TABLE 1. *Dimensions and tolerances for Grade A PTFE plastic tubing*

Descriptive size		Inside diameter		Wall thickness	
American wire gage (AWG)	Fractional	Minimum	Maximum	Nominal	Tolerance (plus or minus)
Number	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
30	----	0.010	0.015	0.009	0.002
28	----	.013	.019	.009	.002
26	----	.016	.022	.009	.002
24	----	.020	.027	.012	.003
22	----	.025	.032	.012	.003
20	----	.032	.040	.016	.003
19	----	.036	.044	.016	.003
18	----	.040	.049	.016	.003
17	----	.045	.054	.016	.003
16	----	.051	.061	.016	.003
15	----	.057	.067	.016	.003
14	----	.064	.074	.016	.003
13	----	.072	.082	.016	.003
12	----	.081	.091	.016	.003
11	----	.091	.101	.016	.003
10	----	.102	.112	.016	.003
9	----	.114	.124	.020	.004
	1/8	.125	.135	.020	.004
8	----	.128	.140	.020	.004
7	----	.144	.158	.020	.004
6	----	.162	.178	.020	.004
5	----	.182	.198	.020	.004
4	----	.204	.224	.020	.004
3	----	.229	.249	.020	.004
	1/4	.250	.270	.020	.004
2	----	.258	.278	.020	.004
1	----	.289	.311	.020	.004
	5/16	.312	.334	.020	.004
0	----	.325	.347	.020	.004
	3/8	.375	.399	.025	.005
	7/16	.438	.464	.025	.005
	1/2	.500	.524	.025	.005
	5/8	.625	.655	.030	.006
	3/4	.750	.786	.035	.007
	7/8	.875	.911	.035	.007
	1	1.000	1.036	.035	.007

TABLE 2. *Dimensions and tolerances for Grade B PTFE plastic tubing*

Descriptive size	Inside diameter		Wall thickness			
			Type I		Type II	
	Minimum	Maximum	Nominal	Tolerance (plus or minus)	Nominal	Tolerance (plus or minus)
Inch	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
1/16	0.057	0.067	0.040	0.005	0.030	0.004
1/8	.120	.130	.040	.005	.030	.004
3/16	.183	.193	.040	.005	.030	.004
1/4	.243	.257	.040	.005	.030	.004
5/16	.304	.320	.040	.005	.030	.004
3/8	.367	.383	.040	.005	.030	.004
7/16	.428	.448	.040	.005	.030	.004
1/2	.490	.510	.043	.006	.030	.004
5/8	.613	.637	.047	.006	.030	.004
3/4	.736	.764	.047	.006	.037	.004
7/8	.859	.891	.053	.007	.040	.005
1	.980	1.020	.060	.007	.045	.007
1 1/4	1.215	1.285	.070	.007	.050	.007
1 1/2	1.460	1.540	.070	.007	.055	.007

3.4. Melting point—The tubing shall have a melting point as specified in table 3 when tested in accordance with 4.4.

3.5. Specific gravity—The tubing shall have a specific gravity as specified in table 3 when tested in accordance with 4.5.

3.6. Tensile strength and elongation—The tubing shall have a tensile strength and elongation as specified in table 3 when tested in accordance with 4.6.

TABLE 3. *Physical requirements for PTFE tubing*

Classification	Melting point	Specific gravity	Tensile strength at 200% elongation (minimum)	Elongation (minimum)	Weight loss (maximum)	Dimensional change (maximum)
Grade A—Electrical	327 ± 10 °C (621 ± 18 °F)	2.13 to 2.24	psi 3000	% 200	% 0.50	% 1.0
Grade B—Chem. & Mech. Types I & II						
Class A—general-purpose	327 ± 10 °C (621 ± 18 °F)	over 2.13	2000	200	0.05	1.0
Class B—flexible	327 ± 10 °C (621 ± 18 °F)	2.13 to 2.18	2000	200	0.05	--
Class C—stress-relieved	327 ± 10 °C (621 ± 18 °F)	over 2.18	1800	200	0.05	1.5

3.7. Weight loss—The tubing shall have a maximum weight loss as specified in table 3 when tested in accordance with 4.7.

3.8. Dimensional stability—The tubing shall have a maximum percent change in any dimension as specified

3.9. Dielectric breakdown voltage (applicable only to Grade A tubing)—The tubing shall have a minimum dielectric breakdown voltage as specified in table 4 when tested in accordance with 4.9.

TABLE 4. *Minimum dielectric breakdown voltage for Grade A, PTFE tubing*

Nominal wall thickness	Dielectric breakdown, minimum
Inch	*Volts*
0.007 to 0.0089 inclusive	10,000
0.009 to 0.0099 inclusive	11,500
0.010 to 0.0119 inclusive	12,500
0.012 to 0.0149 inclusive	14,600
0.015 to 0.0159 inclusive	15,000
0.016 to 0.0199 inclusive	16,300
0.020 and higher	17,000

3.10. Low temperature flexibility—The tubing shall remain flexible and free from cracks when tested in accordance with 4.10.

3.11. Minimum proof pressure (applicable only to Grade B tubing)—The tubing shall have a minimum proof pressure as specified in table 5 when tested in accordance with 4.11.

TABLE 5. *Minimum proof pressure for Grade B, PTFE tubing*

Inside diameter	Minimum proof pressure	
	Type I	Type II
Inch	*psig*	*psig*
0.183 to 0.448 inches	150	100
0.490 to 0.510 inches	150	50
0.613 to 1.540 inches	100	50

3.12. Color stability—The tubing shall exhibit no significant change in color after heat-aging for 5 hours at 200 ± 2 °C (392 ± 4 °F). This can be determined after completion of the heating cycle described in 4.10. The color of the tubing shall be as agreed upon by purchaser and seller.

4. INSPECTION AND TEST PROCEDURES

4.1. General—The inspection and test procedures contained in this section are to be used to determine the conformance of products to the requirements of this Voluntary Product Standard. Each producer or distributor who represents his products as conforming to this Standard may utilize statistically based sampling plans which are appropriate for each particular manufacturing process but shall keep such essential records as are necessary to document with a high degree of assurance his claim that all of the requirements of this Standard have been met. Additional sampling and testing of the product, as may be agreed upon between purchaser and seller, is not precluded by this section.

4.2. Test conditions—The test specimens shall be conditioned and tested in accordance with procedure A of ASTM D 618–61, *Standard Methods of Conditioning Plastics and Electrical Insulating Materials for Testing*.[2]

[2] See footnote 1, page 2.

4.3. Dimensions and tolerances—

4.3.1. Inside diameter—The inside diameter shall be determined in accordance with ASTM D 1675–65, *Standard Methods of Testing Electrical Grade Polytetrafluoroethylene Tubing.*[3]

4.3.2. Wall thickness—The wall thickness shall be determined in accordance with the procedures described in ASTM D 1675–65, except that no individual measurement shall exceed the tolerances specified in tables 1 and 2.

4.4. Melting point—The melting point shall be determined in accordance with section 14 of ASTM D 1457–69, using a shaving from the tubing rather than a molded disk.

4.5. Specific gravity—The specific gravity shall be determined in accordance with method A of ASTM D 792–66, *Standard Methods of Test for Specific Gravity and Density of Plastics by Displacement.*[3]

4.6. Tensile strength and elongation—The tensile strength and elongation shall be determined as specified in 4.6.1, 4.6.2, 4.6.3, and 4.6.4 on five longitudinal specimens and on five transverse specimens using a testing speed of 2 inches per minute. The test results for the longitudinal and the transverse specimens shall be averaged separately. Specimens which break in the jaws of the tensile tester shall be discarded, and new tests shall be made.

4.6.1. Tubing having an inside diameter of 0.625 inch and over—The tensile strength and elongation shall be determined in both the longitudinal and transverse directions in accordance with ASTM D 1457–69.

4.6.2. Tubing having an inside diameter less than 0.625 inch to 0.200 inch, inclusive—The tensile strength and elongation shall be determined in the longitudinal direction in accordance with ASTM D 1457–69, and in the transverse direction in accordance with ASTM D 412–68, *Standard Method of Tension Testing of Vulcanized Rubber.*[3] Transverse specimens shall be ring specimens cut from tubing using the technique provided for heavy-walled tubing greater than 0.060 inch in thickness in paragraph 4.4.1 of ASTM D 412–68.

4.6.3. Tubing having an inside diameter less than 0.200 inch to 0.090 inch, inclusive—The tensile strength and elongation shall be determined in both the longitudinal and transverse directions in accordance with ASTM D 412–68. For longitudinal specimens, the tubing shall be slit parallel to the axis and flattened out, prior to punching out specimens. Specimen shape shall be in the form of a dumbbell as shown in figure 1. Transverse specimens, ¼ inch long, shall be prepared in accordance with paragraph 4.4.1 of ASTM D 412–68.

[3] See footnote 1, page 2.

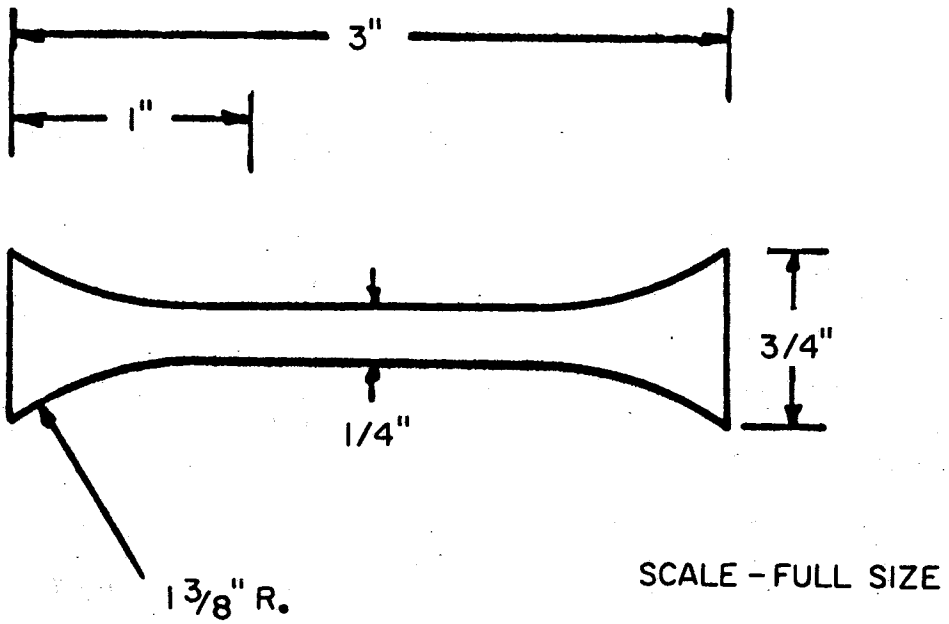

FIGURE 1. *Tensile specimen for tubing of 0.200 inch to 0.090 inch inclusive.*

4.6.4. Tubing having an inside diameter less than 0.090 inch—Specimens shall be tested as filaments. Nonslip type loop knots shall be made in each end of the specimen so that there are 1⅜ inches between the knots of the loops (see figure 2). The loops shall be placed over the drum of a standard wire specimen holder in the tensile machine and pulled in this position.

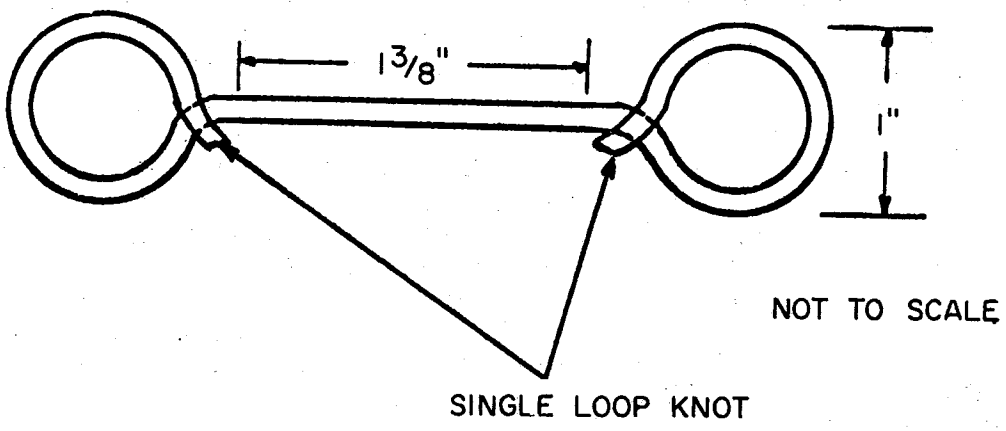

FIGURE 2. *Tensile specimen for tubing less than 0.090 inch.*

4.7. Weight loss—The loss in weight shall be determined in accordance with ASTM D 1675–65, except that the minimum weight of the test specimens shall be 50 grams, and the specimens shall be heated in a forced-draft oven for 3 hours at 300 ± 5 °C (572 ± 9 °F).

4.8. Dimensional stability—Cut a 10-inch specimen of tubing and determine the inner diameter and maximum and minimum wall thicknesses in accordance with 4.3.1. and 4.3.2. Place the specimen

on a steel mandrel having a diameter from 3 to 10 percent less than the inside diameter of the specimen. Mark and number a point at each end of the specimen on a line parallel to the axis of the tubing. Mark three more points at each end of the tubing at 90° intervals from the original points, and measure the linear distance between each set of parallel points using a steel rule or vernier calipers accurate to 0.01 inch. Remove the mandrel and place the specimen on a perforated tray, in an unrestrained position, in an oven for 3 hours at 260 ± 5 °C (500 ± 9 °F). Remove the tray and allow the specimen to cool to 23 ± 1 °C (73.4 ± 1.8 °F). Slip the specimen onto the mandrel and take a new set of measurements. Determine the percent change in the distance between each of the four sets of points. Determine the inner diameter and maximum and minimum wall thicknesses at each end in accordance with 4.3.1 and 4.3.2. The percent change of any dimension shall not exceed that specified in table 3.

4.9. Dielectric breakdown voltage—The dielectric breakdown voltage shall be determined in accordance with ASTM D 1675–55.

4.10. Low temperature flexibility—Three specimens, each 12 inches long, shall be placed in a circulating-air oven at 200 ± 2 °C (392 ± 4 °F) for 5 hours, cooled to room temperature, and then conditioned at minus 55 ± 2 °C (—67 ± 4 °F) for 4 hours. A fixed mandrel, selected in accordance with table 6, shall be conditioned at the same temperature. After completion of the conditioning period and while still maintained at the conditioning temperature, the specimens shall be rapidly wrapped about the mandrel for not less than two complete wraps. The speed of wrapping shall be approximately 2 seconds per 360° wrap.

TABLE 6. *Mandrel dimensions for low temperature flexibility*

Inside diameter of tubing	Diameter of mandrel
inch	inch
0.023 to 0.125	5/16
0.126 to 0.250	3/8
0.251 to 1.000	7/16

4.11. Minimum proof pressure—A 5-foot-long test specimen shall be clamped off at one end and attached at the other end to a pressurizing device capable of maintaining air pressure to within plus or minus 1 psig of the minimum proof pressure specified in table 5 for the duration of the test. Immerse the entire specimen in water, adjust the air to the specified pressure, and maintain this pressure for at least 2 minutes. The presence of any bubbles emanating from the specimen shall constitute failure.

5. IDENTIFICATION

In order that purchasers may identify products conforming to all requirements of this Voluntary Product Standard, producers and distributors may include a statement of compliance in conjunction with their name and address on product labels, invoices,

sales literature, and the like. The following statement is suggested when sufficient space is available:

> This Grade ——, Type ——, Class ——, of polytetrafluoroethylene (PTFE) plastic tubing conforms to all of the requirements established in Voluntary Product Standard PS 52–71, developed cooperatively with the industry and published by the National Bureau of Standards under the *Procedures for the Development of Voluntary Product Standards* of the U.S. Department of Commerce. Full responsibility for the conformance of this product to the standard is assumed by (name and address of producer or distributor).

The following abbreviated statement is suggested when available space on labels is insufficient for the full statement:

> Conforms to PTFE Grade ——, Type ——, Class ——, in PS 52–71, (name and address of producer or distributor).

6. EFFECTIVE DATE

The effective date of this Voluntary Product Standard is the date upon which reference to the Standard may be made by producers, distributors, users and consumers, and other interested parties. Compliance by producers with all of the requirements of this Voluntary Product Standard may not actually occur until some time after its effective date. Products shall not be represented as conforming to this Voluntary Product Standard until such time as all requirements established in the Standard are met. The effective date of this Standard is November 15, 1971.

7. HISTORY OF PROJECT

The Society of the Plastics Industry, Inc., requested the assistance of the Department of Commerce in establishing a Voluntary Product Standard for polytetrafluoroethylene (PTFE) plastic tubing. A proposed draft of the Standard was developed and in May 1971, the proposed Standard was approved by the Standard Review Committee. In July 1971, public announcement was made, and the recommended Voluntary Product Standard was widely circulated to the industry for acceptance. The response to this circulation indicated a consensus of acceptability within the industry as defined in the *Procedures for the Development of Voluntary Product Standards*. Accordingly, the Standard, designated PS 52–71, *Polytetrafluoroethylene (PTFE) Plastic Tubing* was approved for publication by the National Bureau of Standards to be effective November 15, 1971.

Technical Standards Coordinator:
Leslie H. Breden, Office of Engineering Standards Services, National Bureau of Standards, Washington, D.C. 20234

8. STANDING COMMITTEE

The individuals whose names are listed below constitute the membership of the Standing Committee for this Standard. The

function of the committee is to review all proposed revisions and amendments in order to keep this Standard up to date. Comments concerning this Standard and suggestions for its revision may be addressed to any member of the committee or to the Office of Engineering Standards Services, National Bureau of Standards, Washington, D.C. 20234, which acts as secretary for the committee.

Representing Producers

Frank Chaffin (Chairman), W. S. Shamban and Company, 711 Mitchell Road, P.O. Box 397, Newbury Park, Calif. 91320
Edward P. Anderson, Bunnel Plastics, Inc., 12th Street and Ferry Avenue, Camden, N. J. 08104
Myron L. Bailey, Chemplast, Inc., 150 Dey Road, Wayne, N. J. 07470

Representing Distributors

Walter Haller, Almac Plastics, Inc., 6311 Erdman Avenue, Baltimore, Md., 21205
Ronald Hawks, Roberts and Porter, Inc., 4140 West Victoria Avenue, Chicago, Ill. 60646
Frank Futral, Epsco Engineering Company, Box 13157, Houston, Tex. 77019

Users

Maynard Eaves, Hewlett Packard Company, 1501 Page Mill Road, Palo Alto, Calif. 94304
Arron F. McCrary, American Hospital Association, 840 North Lake Shore Drive, Chicago, Ill. 60611
David A. Radovsky, IBM Corporation, Department C–30, 904 Building, Poughkeepsie, N. Y. 14302

9. ACCEPTORS

The producers, distributors, users, and others listed below have individually indicated in writing their acceptance of this Voluntary Product Standard prior to its publication. The acceptors have indicated their intention to use this Standard as far as practicable but reserve the right to depart from it when necessary. The list is published to show the extent of recorded public support for this Standard.

PRODUCERS

American Hoechst Corporation, Commack, N.Y.
Bunnell Plastics, Inc., Camden, N.J.
Chemplast, Inc., Wayne, N.J.
CIMCO Wire and Cable Company, Allendale, N.J.
Crane Packing Company, Morton Grove, Ill.
Edlon Plastics, Inc., Levittown, Pa.
E. I. duPont de Nemours Company. Wilmington, Del.
Enflo Corporation, Maple Shade, N.J.
Fluorocarbon Company, The, Rosemont, Ill.
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Kessler Products Company, Inc., Youngstown, Ohio
Modern Industrial Plastics Division, Dayton, Ohio
Newage Industries, Inc., Jenkintown, Pa.
Plastomer Corporation, Newtown, Pa.
Polymer Corporation, The, Reading, Pa.
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Shamban, W. S., and Company, Los Angeles, Calif.
Sperry Rubber and Plastics Company, Brookville, Ind.
Surf Chemical, Inc., Hackettstown, N. J.
Technical Fluorocarbons Engineering, Inc., Warwick, R. I.
Teledyne Thermatics, Elm City, N. C.
Teleflex Inc., Dover, N. J.
Wireonics Products Company, Winnetka, Ill.

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Almac Plastics, Baltimore, Md.
American Durafilm Company, Newton Lower Falls, Mass.
American Hospital Association, Chicago, Ill.
American Standards Testing Bureau, Inc., New York, N. Y.
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Canadian Industries Limited, Toronto, Canada
Carlisle Corporation, Tarrytown, N. Y.
Celluplastics, Inc., Fitchburg, Mass.
Chase Company, The, Union City, Calif.
Cobon Plastics Corporation, Newark, N. J.
Components Engineering Radiation Inc., Melbourne, Fla.
Cope Plastics Illinois, Inc., Godfrey, Ill.
Cutler Hammer Inc., Milwaukee, Wis.
Dilectrix Corporation, Farmingdale, N. Y.
Electro Chemical Engineering and Manufacturing Company, Emmaus, Pa.
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Foote Mineral Company, Exton, Pa.
Fowler, R. W. and Associates, Inc., Atlantic Beach, Fla.
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Glidden-Durkee, Cleveland, Ohio
Goodrich, B. F., Company, The, Akron, Ohio
Goodyear Tire and Rubber Company, The, Akron, Ohio
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Gulf Research and Development Company, Pittsburgh, Pa.
Hercules, Inc., Wilmington, Del.
Hewlett-Packard Company, Palo Alto, Calif.
Honeywell, Inc., Fort Washington, Pa.
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IBM Corporation, Poughkeepsie, N. Y.
ICI America, Inc., Stamford, Conn.
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LFE Corporation, Hamden, Conn.
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Lockheed-Georgia Company, Marietta, Ga.
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Merck and Company, Inc., Rahway, N.J.
Metalweld, Inc., Philadelphia, Pa.
Mine Safety Appliances Company, Pittsburgh. Pa.
Modern Plastics and Glass, Bridgeport, Conn.
Natvar Corporation, Woodbridge, N. J.
Omaha Testing Laboratories, Inc., Omaha, Neb.
PPG Industries, Pittsburgh, Pa.
Pennwalt Corporation, King of Prussia, Pa.
Pittsburgh Testing Laboratory, Pittsburgh, Pa.
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Proctor and Gamble Company, Cincinnati, Ohio
Quantum, Inc., Wallingford, Conn.
RCA Corporation, Camden, N. J.
Redmond Plastics, Inc., Marion, N. Y.
Roberts and Porter, Inc., Chicago, Ill.
S and S Manufacturing Company, Rahway, N. J.
Scott Graphics, Inc., Holyoke, Mass.
Sparta Manufacturing Company, Dover, Ohio
Tektronix, Inc., Beaverton, Oreg.
Texplast International Company, Berkeley Heights, N. J.
Triplex Rubber and Supply Company, Houston, Tex.
U.S. Industrial Chemicals Company, Tuscola, Ill.
United States Testing Company, Inc., Hoboken, N. J.
Universal Oil Products Company, Des Plaines, Ill.
Ventron Corporation, Beverly, Mass.
Vulcan Materials Chemicals Division, Wichita, Kans.

FEDERAL, STATE, AND LOCAL GOVERNMENTS

Arizona, State of, Phoenix, Ariz.
Florida, State of, Tallahassee, Fla.
General Services Administration, Washington, D. C.
Nebraska, State of, Lincoln, Neb.
North Carolina, State of, Raleigh, N. C.
Oregon, State of, Salem, Oreg.
Pennsylvania, Commonwealth of, Bureau of Standards, Harrisburg, Pa.
Texas State Board of Control, Austin, Tex.
U.S. Department of Agriculture, Washington, D.C.
U.S. Department of Health, Education, and Welfare, Washington, D.C.